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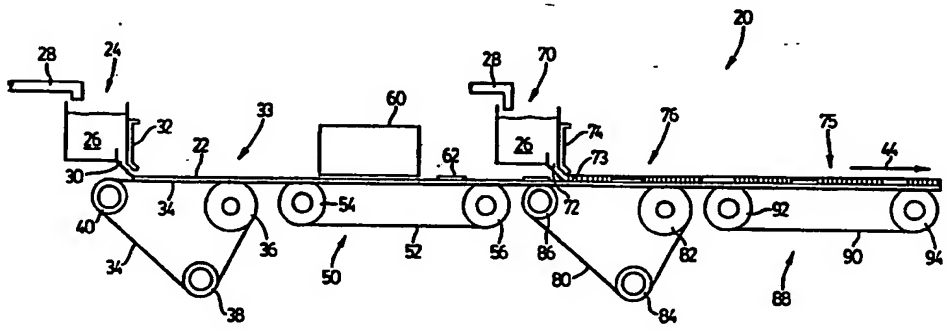

(57) Abstract

Apparatuses and a method are disclosed for making an authenticated web formed from fibrous material. In one embodiment, the apparatus (20) includes a head box (24) holding a pulp mixture (26) for depositing a base web (22) on a Fourdrinier table (33) whereon the fibres in the base web are aligned and the base web is dried. An optically variable material applicator (60) is located above the base web and deposits optically variable material thereon. The applicator does this either in the form of a powder spray, or by embedding optically variable articles into the base web. Once this is done, the base web passes beneath a second head box (70) which deposits a thin fibrous layer over the optically variable material and the base web. The fibrous layer and the base web are dried to form the finished authenticated fibrous web. The thickness of the resulting fibrous web is controlled so that light is able to pass through the fibrous layer allowing the properties of the optically variable material to be utilized. In another embodiment, a cylinder mould machine (322) is used to form the base web on a belt (328) which supports and transports the base web to the optically variable material applicator and then to the second head box. Alternatively, the base web with the optically variable material thereon may be conveyed to a laminator wherein a fine web of fibrous material is placed over the base web and optically variable material to form the authenticated fibrous web.

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APPARATUS AND METHOD OF MAKING AN AUTHENTICATED WEB FORMED OF FIBROUS MATERIAL

TECHNICAL FIELD

The present invention relates to an apparatus and method of making an authenticated web formed of fibrous material.

BACKGROUND ART

Authenticating valuable articles to prevent counterfeiting is a common practise. For valuable articles such as coins, bank notes and the like, it is common to engrave intricate designs on the article to identify the article as authentic. However, this method has not always offered sufficiently discriminating tests to prevent spurious articles from being passed off as authentic ones.

To overcome the above disadvantages associated with paper currency, the use of optical thin film coatings on bank notes and similar fibrous substrates has been implemented. For example, United States Patent No. 3,858,977 to Baird et al and assigned to Canadian Patent and Development Limited discloses an optical interference authenticating means including a multi-layer optical thin film filter disposed on the paper currency to be authenticated. The optical thin film layers have a known characteristic spectral reflectance and a different known characteristic spectral transmittance both of which vary with the angle of incident light. The optical thin film layers are deposited on a carrier using vacuum deposition techniques to form the filter. The filter is then adhered to the paper currency via suitable adhesive means to authenticate the paper currency.

The design of the optical thin film layers is such that the primary reflectance peak of the filter is located in the red part of the spectrum at normal angles of incident light. Upon tilting of the authenticating means to change the angle of incident light, the primary reflectance peak shifts from the red to the gold or green part of the spectrum. The authenticating means therefore exhibits a red to green colour change upon tilting. This type of authenticating means when placed on the paper currency, allows an individual at a glance to perform a check to determine if the document is authentic.

U.S. Patent No. 4,705,356 to Berning et al also discloses an optically variable article to be applied to paper currency and the like. This article includes an optically thick, substantially transparent element carrying a colorant. A multi-layer interference coating is carried on one surface of the transparent element. The colorant serves to modify in a subtractive mode, the colour of the article at normal angles of incident light and the colour shift with changing angles of incident light as seen by reflection or transmission. The layers of the interference coating and the colorant are selected so that the article exhibits an abrupt colour change as the angle of incident light changes.

U.S. Patent Nos. 4,705,300, 4,779,898 and 4,930,866 to Berning et al similarly disclose an optically variable article for application to paper currency and the like having a gold to green colour shift. The layers of the interference coating are selected so that the article at normal angles of incident light has a coppery-gold colour and changes to a vivid green colour at another non-normal angle of incident light. At yet another non-normal angle of incident light, the article has no colour.

Although these types of authenticating means work satisfactorily, the authenticating article is placed on top of the paper currency. This makes the counterfeiting process easier if the counterfeiter is capable of developing

articles which exhibit the optical characteristics of authentic, optically variable articles.

To guard against this problem, paper documents with material embedded therein have been considered. For example, European Patent Application No. 90305679 to Edwards and assigned to Portals Limited discloses a paper document having a metal strip embedded in it. The metal strip is formed in the paper document such that the metal strip is concealed in some places and exposed in other places.

U.S. Patent No. 4,943,093 to Melling et al and assigned to Portals Limited discloses a paper document having a security device embedded in it. The security device comprises a flexible, water-impermeable substrate with a layer of metal on one or both sides of the substrate. On one side of the security device, a continuous metal path along its length is provided. However, the device has metal-free portions of between 10% and 50% of the area of the device. The metal-free portions along the length of the device provide a repeating pattern, design or the like with at least some of the metal-free portions across the transverse direction of the security device being wholly surrounded by metal. The security device may be a strip or thread and this may be positioned in a window or in an aperture where two windows are impartial or complete register.

U.S. Patent No. 4,534,398 to Crane and assigned to Crane & Co. discloses a security paper document incorporating counterfeit deterrent optical variable devices. The optical variable devices display their optically active properties in reflectance when there are changes in the angle of incident light with respect to the eye of the viewer. The optical variable devices are adhered to a carrier paper web and then the carrier paper web is brought into contact with a base web. An embedment roll presses the two webs together to push the

optically variable devices into the base web while the base web fibres are unconsolidated and pliable.

Although the patents assigned to Portals Limited and Crane & Co. disclose methods of authenticating a paper document during its production, improved methods of doing this are continually being sought.

It is therefore an object of the present invention to provide a novel apparatus and method of forming an authenticated web formed of fibrous material.

DISCLOSURE OF THE INVENTION

According to the present invention there is provided an apparatus for making an authenticated web formed of fibrous material comprising:

fibrous material dispensing means depositing fibrous material on a moving belt to form a base web;

an applicator downstream of said dispensing means applying optically variable material to a surface of said base web, said optically variable material changing colours with varying angles of incident light; and

means downstream of said applicator for overlying the surface of said base web with additional fibrous material to cover said optically variable material and said base web and form said authenticated web whereby said fibrous material covering said optically variable material is sufficiently thin to permit light to pass therethrough and contact said optically variable material.

Preferably, the optically variable material applied to the base web is in powder form. In one embodiment, it is preferred that the applicator includes a pressurized sprayer located above the base web and a mask positioned between the sprayer and the base web. The sprayer discharges the powder

towards the mask and an aperture in the mask allows the powder to contact the base web. The sprayer can be operated continuously and the mask can be fixed relative to the base web to apply a continuous strip of optically variable material to the base web. Alternatively, the mask can include a plurality of spaced, geometrically shaped apertures and can be moved over the base web at the same speed thereas. In this case, the sprayer is operated continuously whereby the optically variable material is applied to the base web at discrete locations only when the apertures pass beneath the sprayer.

In another embodiment, it is preferred that the powder is immersed in a liquid carrier and the applicator applies the optically variable material to the base web via an off-set printing or silk screening technique. In yet another embodiment, the optically variable material is in the form of discrete articles and the applicator contacts the base web to impress the optically variable articles in the base web. In this instance, it is preferred that the applicator includes a stamping unit having a vertically movable head carrying the optically variable article. The head contacts the base web and impresses the optically variable article therein. Alternatively, the optically variable material may be in the form of a continuous strip and the applicator may include a roller carrying the strip and guide means. The roller applies the strip of optically variable material to the base web and the guide means impresses the strip therein.

In yet another embodiment, the optically variable material is carried on a carrier film movable over the base web and the applicator includes means to generate a beam of radiation. The beam of radiation is directed on the carrier to fragment the optically variable material and separate the optically variable material from the carrier to deposit the fragments of optically variable material on the base web.

In one instance, it is preferred that the carrier is moved continuously over the base web at the same speed thereas and the means to generate a beam of radiation is operated continuously to apply a strip of optically variable material to the base web. In another instance, it is preferred that the means to generate the beam of radiation is pulsed to apply discrete marks of optically variable material to the base web.

The fibrous material dispensing means may be in the form of a head box depositing the fibrous material on a Fourdrinier table which carries the base web to the applicator. Alternatively, a cylinder mould machine may be used to deposit the fibrous material on a Formex® which carries the base web to the applicator. The means downstream of the applicator may be an additional head box or may be a laminator receiving a fine web of fibrous material and overlying the base web and the optically variable material with the fine web to form the authenticated web.

According to another aspect of the present invention there is provided in a fibrous web making process wherein fibrous material is deposited on a moving belt to consolidate fibres therein and form a base web further including the steps of applying optically variable material which changes colour with varying angles of incident light to a surface of said base web and covering said surface and said optically variable material with additional fibrous material to form a fibrous web, said additional fibrous material being sufficiently thin to permit light to pass therethrough and contact said optically variable material.

Preferably, the optically variable material is in the form of a powder and is applied to the base web either by spraying, off-set printing, silk screening, impressing or laser transfer techniques.

The present invention provides a novel apparatus and method of authenticating a fibrous web using optically variable material that changes colour with varying angles of incident light. The apparatus embeds the optically variable material in the fibrous web using the simple technique of applying the optically variable material to a base web and overlying the optically variable material and the base web with additional fibrous material that is thin enough to permit light to pass, allowing the utilization of the optical properties of the optically variable material. The optically variable material can be applied to the base web at discrete locations to form individual marks or can be applied continuously to form strips. This facilitates the authentication process since the optically variable material is applied in situ during the fibrous web making process.

BRIEF DESCRIPTION OF THE DRAWING

Embodiments of the present invention will now be described more fully with reference to the accompanying drawings in which:

Figure 1a is a top plan view of a paper document with optically variable material therein;

Figure 1b is a section of the document illustrated in Figure 1a taken along line a-a;

Figure 2 is a side view of a paper making machine including a device for applying optically variable material during formation of a paper web;

Figure 3 is a perspective view of one embodiment of the device for applying optically variable material to the paper web used in the paper making machine illustrated in Figure 2;

Figure 4 is a perspective view of another embodiment of the device for applying optically variable material to the paper web used in the paper making machine illustrated in Figure 2;

Figure 5 is a side view of yet another embodiment of the device for applying optically variable material to the paper web used in the paper making machine illustrated in Figure 2;

Figure 6 a top view of the device illustrated in Figure 5;

Figure 7 is a side view of still yet another embodiment of the device for applying optically variable material to the paper web used in the paper making machine illustrated in Figure 2;

Figure 8 is a top view of the device illustrated in Figure 7;

Figure 9 is a side view of still yet another embodiment of the device for applying optically variable material to the paper web used in the paper making machine illustrated in Figure 2;

Figure 10 is a top view of the device illustrated in Figure 9;

Figure 11 is a side view of another embodiment of a portion of a paper making machine including a device for applying optically variable material;

Figure 12 is a side view of another embodiment of a machine for making a base web on which optically variable material is to be applied;

Figure 13 is a side view of another embodiment of a machine for making a base web on which optically variable material is to be applied;

Figure 14 is a section of an embodiment of a portion of an authenticated web made using one of the machines illustrated in Figures 12 and 13; and

Figure 15 is a section of another embodiment of a portion of an authenticated web made using the device illustrated in Figures 7 and 8.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring now to Figure 1, an authenticated document is shown and is generally indicated by reference numeral 10. In this example, the document 10 is in the form of paper currency cut from a continuous paper web, although it should be realized by those of skill in the art that any other type of valuable article formed of fibrous material can constitute the authenticated document.

These other types of articles may include for example, passports, visas, travel documents, identity cards and the like. Embedded within the paper document 10 is optically variable material 12. The optically variable material 12 exhibits a colour change with changing angles of incident light as will be described. This enables an individual to determine at a glance, an authentic document 10 from a counterfeit one by tilting the document 10 and viewing the colour change of the material 12.

The reflected colour from a white light source that one perceives depends on the colour of the document 10 on which the material 12 is deposited and the optical properties of the material 12 itself. For the material 12 to exhibit a colour change as light is transmitted or reflected from the material and which changes colour with varying angles of incident light, the material must be designed to have a characteristic spectral reflectance and a different characteristic spectral transmittance. The colouring on the surface of the document 10 beneath the material 12 absorbs some of the light transmitted through the material and this effects the colour properties of the material 12.

The aforementioned prior art patents to Baird et al and Berning et al describe different optically variable articles formed of multi-layer optical thin films which exhibit a colour change (typically from red or gold to green) with varying angles of incident light. In the present invention, optically variable material similar to these articles can be used during the formation of the fibrous web. Various embodiments of an apparatus for forming an authenticated fibrous web from which the authenticated document 10 having optically variable material embedded therein may be made, will now be described.

Referring to Figure 2, an apparatus 20 for forming a fibrous web having optically variable material embedded therein is shown. As can be seen, the apparatus 20 includes a head box 24 receiving a pulp mixture 26 via a feed line

28. The head box 24 has an angled outlet 30 with a slice 32 to control the flow of pulp mixture 26 out of the head box 24. The pulp mixture 26 leaving the outlet 30 is delivered on a Fourdrinier table 33 in the form of a base web 22. In the context of the present invention, base web refers to base paper fibres when rough and saturated with water (at least to some extent) supplied from the head box 24. The Fourdrinier table 33 supports and transports the base web, allows the papers fibres in the base web to align and allows water to be removed from the base web by vacuum. To achieve this, the Fourdrinier table 33 includes a moving, endless, mesh, wire belt 34 wound around a drive roller 36 and a pair of idler rollers 38 and 40 respectively. The drive roller 36 is rotated by a motor (not shown) to move the wire belt 34 so that the base web 22 moves downstream of the head box 24 in the direction of arrow 44. Adjacent the drive roller 36 are vacuum elements 42 which remove water from the base web 22. During this process, the head box 24 continuously delivers pulp mixture 26 onto the wire belt 34 so that a continuous base web is formed.

Downstream of the Fourdrinier table 33 is a web drive 50 including a drive belt 52 supporting the undersurface of the base web 22. The belt 52 is wound around a pair of rollers 54 and 56 respectively. Located above the base web 22 adjacent the web drive 50 is an optically variable material applicator 60. The applicator 60 is vertically spaced from the base web 22 and applies optically variable material 60 to the base web while the fibres therein are pliable. Various embodiments of applicators 60 for performing this operation will be discussed herein.

Downstream of the roller 56 is another head box 70. Similar to the head box 24, the head box 70 has an angled outlet 72 with a slice 74 to control the flow of pulp mixture out of the head box 70. The thickness of pulp mixture leaving the outlet 72 is controlled so that the optically variable material 62 on the base web 22 is covered with a fibrous layer 73 to form an authenticated

fibrous web 75 while ensuring that light can pass through it in order to take advantage of the colour changeability of the material 62.

Beneath the head box 70 is located another Fourdrinier table 76 which supports and transports the fibrous web 75. Similarly, the table 76 includes wire mesh belt 80 wound around a drive roller 82 and a pair of idler rollers 84 and 86 respectively. A motor (not shown) rotates the drive roller 82 to move the belt 80 and therefore, the fibrous web. Vacuum elements 87 are adjacent the drive roller 82 to remove more water from the fibrous web 75. Downstream of the drive roller 82 is another web drive 88 including a drive belt 90 supporting the undersurface of the fibrous web. The belt 90 is wound around a pair of rollers 92 and 94. The web drive 88 moves the fibrous web 75 to appropriate finishing areas wherein the thickness of the fibrous layer 73 covering the optically variable material 62 can be altered, if necessary, to ensure that the fibrous web 75 exhibits the proper optical characteristics with varying angles of incident light.

Figure 3 better illustrates one embodiment of the optically variable material applicator 60 which makes use of spraying to apply the optically variable material to the base web 22. The applicator 60 includes a gas pressurized sprayer 100 storing flakes of optically variable material 62 formed from layers of optical thin film material. Each flake is of a size and aspect ratio to maintain its optical properties with changing angles of incident light. Below the sprayer 100 is a fixed mask 102 with an aperture 104 provided through it. As the base web 22 passes beneath the applicator 60, the sprayer 100 discharges the optically variable material towards the mask 102. The optically variable material 62 passes through the mask 102 via the aperture 104 onto the base web 22. Since the sprayer 100 is operated continuously in this process, the base web 22 has a continuous optically variable strip 106 applied to it.

Figure 4 shows another embodiment of the applicator 60' similar to that illustrated in Figure 3. In this embodiment, like reference numerals will be used to indicate like components with a "'" added for clarity. As can be seen, the applicator 60' includes a liquid pressurized sprayer 100' storing flakes of optically variable material 62. A mask 102' is located below the sprayer 100' and is in the form of a belt wound about a pair of laterally spaced guides 108. Although not shown, the mask 102' is moved by a suitable drive so that it moves over the base web at the same speed as the base web 22. The mask 102' has a plurality of spaced, different, geometrically shaped apertures 104' provided through it. In operation, as the base web 22 is moved by the belt 52, the mask 102' is moved over the base web 22 at the same speed. The sprayer 100' is operated continuously and therefore discharges optically variable material towards the mask. When an aperture 104' passes beneath the sprayer 100', the optically variable material is applied to the base web 22 as discrete marks 106' in the shape of the aperture.

The operation of the sprayer 100' may also be timed with the movement of the mask 102' to spray the optically variable material towards the mask only when an aperture 104' in the mask is positioned beneath the sprayer. This has the advantage in that less optically variable material is required but requires more sophisticated control equipment to time the operation of the sprayer with the position of the apertures in the mask 102'. When using a spraying technique to apply the optically variable material to the base web 22, the orientation of powder needs to be controlled so that flakes of optically variable material generally lie flat on the base web 22 and maintain their optical properties.

Figures 5 and 6 illustrate yet another embodiment of the applicator 60 which makes use of an off-set printing technique to apply the optically variable material to the base web 22. In this embodiment, the optically variable

material 62 is held in a fountain 120 vertically spaced above the base web 22. The optically variable material is immersed in either water or a solvent 123 suitable for application purposes. A gravure cylinder 124 having patterns 126 on its outer surface has a portion of its outer surface submersed in the fountain 120. Thus, as the cylinder 124 rotates the entire surface of the cylinder becomes coated in the solution. A doctor blade 128 is positioned adjacent the gravure cylinder 124 to control the thickness of the coating carried by the cylinder 124.

The gravure cylinder 124 contacts a contra-rotating transfer roller 130 and deposits the coating thereon only when the etched patterns 126 on the gravure cylinder 124 contact the transfer roller 130. The transfer roller 130 in turn contacts a printing roller 132 and transfers the coating on its outer surface to the printing roller. The printing roller 132 in turn contacts the base web 22 to apply the optically variable material on its outer surface to the base web. The pattern of the optically variable material applied to the base web 22 is in the same pattern as the patterns 126 on the gravure cylinder 124. On the undersurface of the paper web 22 directly below the printing roller 132 is an impression roller 134 which ensures good contact between the base web 22 and the printing roller 132 so that the optically variable material 62 is transferred to the paper web 22. If the pattern on the gravure cylinder 124 extends along the entire circumference of the cylinder, a continuous optically variable strip 136 is applied to the base web 22. Alternatively discrete etchings can be provided on the gravure cylinder 124 to apply individual optically variable marks 138 to the base web 22. Although not shown, rather than using the off-set printing technique described above, a silk screening technique can be used to apply the optically variable material to the base web 22.

Figures 7 and 8 show yet another applicator 60 which makes use of embedding techniques to apply the optically variable material 62 to the surface

of the base web 22. This unit includes two devices 150 and 152 respectively for embedding the material into the base web 22 in different patterns. One of the devices 150 is in the form of a stamping unit 154 having a vertically movable plunger 156 with an application head 158 at its lower end. In this embodiment, the optically variable material is in the form of individual optically variable articles. A cartridge dispenser (not shown) is associated with the stamping unit 154 and stores the optically variable articles to be embedded in the base web 22. The plunger 156 is movable over the dispenser so that an optically variable article may be removed from the dispenser. To achieve this, a vacuum is created at the application head 158 so that the optically variable article can be picked up by the plunger. The plunger 156 is then moved to contact the base web 22 and the vacuum is shut off so that when the application head 158 contacts the base web 22, the optically variable article carried on the application head 158 is embedded in the base web 22. This allows discrete optically variable marks 168 to be embedded in the base web 22.

The other device 152 includes a roller 160 carrying a ribbon 162 of optically variable material on a plastic carrier, paper carrier or the like. The roller 160 is rotated by a motor (not shown) to unwind the ribbon 162. Guide rollers 164 and 166 position and press the ribbon into the base web 22 as it passes beneath the device 152. This allows a continuous strip 170 of optically variable material to be embedded into the base web 22.

Figures 9 and 10 illustrate still yet another embodiment of the applicator 60 which makes use of a laser transfer process to apply the optically variable material to the base web 22. In this embodiment, the optically variable material 62 is carried on a polyester carrier film 200 wound between a pair of rollers 202 and 204 respectively. A motor (not shown) rotates roller 204 to unwind the film 200 from roller 202 and wind it about roller 204. A laser 206 is positioned between the rollers and directs a coherent horizontal beam of

radiation 207 towards a bending prism 208. The bending prism 208 changes the direction of the beam of radiation 207 by 90 degrees towards the film 200. Before the beam of radiation 206 impinges on the film, it passes through a fixed mask 214 having an aperture 212 and is then focused by a lens 210 so that the shape of the light impinging on the film 200 is controlled. The power and the wavelength of the laser 206 is controlled so that the optically variable material fragments and falls from the carrier film 200 onto the base web 22.

If a continuous strip 220 of optically variable material 62 is to be applied to the base web 22, the laser 206 should be operated continuously and the film 200 should moved over the base web 22 at the same speed as the base web. If it is desired to apply the optically variable material 62 to the base web 22 in the form of discrete, geometrically shaped marks 222, the laser 206 can be pulsed. Alternately, the optically variable material 62 can be moved in stages over the base web 22 or a movable mask 24 similar to that shown in Figure 4 can be used.

Referring now to Figure 11, another embodiment of a portion 300 of an apparatus for covering the base web 22 having optically variable material 62 thereon with additional fibrous material is shown. The portion 300 is located downstream of the head box 24 and Fourdrinier table 33. As can be seen, downstream of the web drive 50 and the applicator 60 is another roller 304 around which the base web 22 having the optically variable material 62 thereon is wound. A second fine fibrous web 306 passes around a guide roller 308 and winds around the roller 304 to overlie the surface of the base web 22 on which the optically variable material is located. An impression roller 310 adjacent the roller 304 ensures that the base web 22 and fine fibrous web 306 adhere to form a laminated fibrous web 75. The laminated fibrous web 75 passes around another guide roller 312 and proceeds to a finishing section wherein the thickness of the fine fibrous web 306 overlying the optically variable material

is altered, if necessary, to ensure that it is sufficiently thin to permit light to pass therethrough and contact the optically variable material 62.

Figure 12 shows another apparatus 320 for forming a base web 22 on which optically variable material may be deposited. In this embodiment, rather than using a head box 24 to apply the pulp mixture 26 on the Fourdrinier table 33, a cylinder mould machine 322 is used. As can be seen, the cylinder mould machine 322 includes a vat 324 receiving the pulp mixture 26 from a feed line (not shown). The vat 324 is in the form of an open cylindrical trough in which a cylinder mould 326 is located. The cylinder mould 326 is in the form of a cylindrical, mesh roller and is partially submersed in the pulp mixture 26. The vat and cylinder mould are positioned below an endless belt 328 such as that manufactured and sold under the name Formex®. The cylinder mould 326 contacts the belt 328 adjacent a couch roller 330. The belt 328 is wound around the couch roller 330, a drive roller 332 as well as a pair of idler rollers 334 and 336 respectively. Vacuum elements 338 are located below the belt 328 just upstream of the drive roller 332.

In operation, as the cylinder mould 326 rotates a film of pulp coats the wire mesh roller. Water is removed from the inside of the cylinder mould 326 while a layer of fibres coats the outside of the mould. The couch roller 330 which ensures good contact between the belt 328 as it winds around the rollers and the cylinder mould 326 causes the fibres to be peeled off the cylinder mould 326 onto the belt 328 to form a base web 22. The belt in turn, carries the base web 22 towards the drive roller 328 wherein it is conveyed to one of the applicators 60 previously described. This allows the base web 22 to be authenticated with optically variable material 62.

Figure 13 shows another embodiment of an apparatus 348 for forming a base web 22 that is virtually identical to that shown in Figure 2 with the

exception that it makes use of a Dandy roller 350 to form watermarks in the base web 22 before optically variable material 62 is applied to the base web 22. As is known to those of skill in the art, the Dandy roller 350 has an emboss on it which displaces fibres in the base web 22 and produces areas of varying fibre densities to form watermarks on the base web 22 as the Dandy roller 350 rotates. A watermark is only observed in transmission where the amount of light transmitted through the fibrous web varies according to the local density of the web fibres. In other words, areas with a high density of fibres transmit little light and appear dark whereas areas with a low density of fibres transmit relatively more light and appear translucent.

Figure 14 shows a portion of a fibrous web 75 on which watermarks 351 and in which optically variable material 62 in the form of discrete marks have been formed. The varying density of portions of the fibres in the fibrous web due to the watermarks 351 and the depth of the optically variable material 62 in the fibrous web, cause different portions of the fibrous web 75 to have different light reflective and light transmissive properties R_1 to R_2 and T_1 to T_4 respectively. This produces interesting colour effects as the angle of incident light changes.

If it is desired to form watermarks using the apparatus illustrated in Figure 12, the desired watermark features must be embossed on the mesh of the cylinder mould 326. The recessed areas of the embossed pattern on the cylinder mould 326 attract more fibres than other areas of the cylinder mould 326 and this creates different fibre density areas in the base web 22 deposited on the belt 328. This results in the formation of watermarks 351 in the fibrous web.

Rather than applying the optically variable material 62 to the base web 22 in areas where the watermarks 351 have previously been formed, if a

printing technique is used such as that shown in Figures 5 and 6, the optically variable material may be applied to the base web 22 by the Dandy roller 350 at the same time as the watermark is being formed. The optically variable material can be applied to the Dandy roller 350 by way of a transfer roller.

Alternatively, the optical variable material 62 may be applied to the base web 22 with a neutral filler that causes local variations in the density of the fibres in the base web. In this case, the optically variable material will be in powder form and will be combined with the filler in a liquid solution so that it may be applied to the base web 22 via a spraying or printing technique. When the filler and optically variable material is applied to the base web 22, the filler creates areas of low fibre density thereby forming the optically variable watermarks. In this instance, the use of the Dandy roller or emboss on the cylinder mould 326 are not required.

Referring to Figure 15, another embodiment of a portion of an authenticated fibrous web 75 is shown. In this embodiment, multiple optically variable material 62 in the form of discrete articles 168 are embedded in the base web 22 and positioned so that the articles are at different depths within the fibrous web 75 with at least a portion of one of the articles overlying the other. By ensuring that the optical characteristics of each of the articles 168 are different, interesting colour effects can be achieved. To achieve this, two applicators 60 separated by a head box are required. The first applicator applies the deepest optically variable article to the base web 22 and the head box overlies it with a thin layer of fibrous or clear material. The second applicator then applies the other optically variable article to the base web. The operation of the two applicators must be timed to ensure that the optically variable articles overlie one another as desired. Once the optically variable articles are in place on the base web, the base web is conveyed to the head box 70 or to the roller 304 so that the authenticated web 75 may be formed.

Alternatively, one of the optically variable articles can be embedded in the fibrous web and the other article can be applied to the surface of the fibrous web with at least a portion of one of the optically variable articles overlying the other.

What is claimed is:

1. An apparatus for making an authenticated web formed of fibrous material comprising:

fibrous material dispensing means depositing fibrous material on a moving belt to form a base web;

an applicator downstream of said dispensing means applying optically variable material to a surface of said base web, said optically variable material changing colours with varying angles of incident light; and

means downstream of said applicator for overlying the surface of said base web with additional fibrous material to cover said optically variable material and said base web and form said authenticated web whereby said fibrous material covering said optically variable material is sufficiently thin to permit light to pass therethrough and contact said optically variable material.

2. An apparatus as defined in claim 1 wherein said optically variable material applied to said base web is in powder form.

3. An apparatus as defined in claim 2 wherein said applicator includes a pressurized sprayer located above said base web and a mask positioned between said sprayer and said base web, said sprayer discharging said powder towards said mask, an aperture in said mask allowing said powder to contact said base web.

4. An apparatus as defined in claim 3 wherein said sprayer is operated continuously and said mask is fixed relative to said base web to apply a continuous strip of optically variable material to said base web.

5. An apparatus as defined in claim 3 wherein said mask includes a plurality of spaced, geometrically shaped apertures and is movable over said base web at the same speed thereas, said sprayer operating continuously

whereby optically variable material is applied to said base web at discrete locations when said apertures pass beneath said sprayer.

6. An apparatus as defined in claim 3 wherein said mask includes a plurality of spaced, geometrically shaped apertures and is movable over said base web at the same speed thereas, said sprayer being timed with said mask and discharging said optically variable material when an aperture in said mask is located beneath said sprayer.

7. An apparatus as defined in claim 2 wherein said powder is immersed in a liquid carrier and said applicator applies said optically variable material to said base web via an off-set printing or silk screening technique.

8. An apparatus as defined in claim 7 wherein said applicator includes a gravure roller contacting said powder and liquid carrier, a transfer roller contacting said gravure roller and a printing roller contacting said transfer roller and said base web, said printing roller applying optically variable material to said base web transferred between each of said rollers.

9. An apparatus as defined in claim 1 wherein said optically variable material is in the form of discrete, optically variable articles and said applicator contacts said base web to impress said optically variable articles in said base web.

10. An apparatus as defined in claim 9 wherein said applicator includes a stamping unit having a vertically movable head carrying said optically variable articles, said head contacting said base web and impressing said optically variable articles therein.

11. An apparatus as defined in claim 1 wherein said optically variable material is in the form of a continuous strip, said applicator includes a roller carrying said strip and guide means, said roller applying said strip to said base web and said guide means impressing said strip therein.

12. An apparatus as defined in claim 1 wherein said optically variable material is carried on a carrier film movable over said base web, said applicator including means to generate a beam of radiation, said radiation being directed to said carrier to fragment said optically variable material and separate said material from said carrier to apply said fragments to said base web.

13. An apparatus as defined in claim 12 wherein said carrier is moved continuously over said base web at the same speed thereas and said means to generate a beam of radiation is operated continuously to apply a strip of optically variable material to said base web.

14. An apparatus as defined in claim 12 wherein said means to generate said beam of radiation is pulsed to apply discrete marks of optically variable material to said base web.

15. An apparatus as defined in claim 9 wherein said applicator impresses at least one optically variable article into said base web and applies another optically variable article to said fibrous web so that so that at least a portion of said optically variable articles overlie one another.

16. An apparatus as defined in claim 15 wherein both of said optically variable articles are embedded in said base web at different depths.

17. An apparatus as defined in claim 1 further including means to form a watermark on said base web in the area on which said optically variable material is applied.

18. An apparatus as defined in claim 17 wherein said optically variable material is applied to said base web after said watermark has been formed.

19. An apparatus as defined in claim 17 wherein said watermark and said optically variable material are formed on said base web simultaneously

20. In a fibrous web making process wherein fibrous material is deposited on a moving belt to consolidate fibres therein and form a base web further including the steps of applying optically variable material which changes colour with varying angles of incident light on a surface of said base web and covering said surface and said optically variable material with additional fibrous material to form a fibrous web, said additional fibrous material being sufficiently thin to permit light to pass therethrough and contact said optically variable material.

21. The process of claim 20 wherein said optically variable material is in the form of a powder.

22. The process of claim 21 wherein said optically variable material is sprayed on said base web with a suitable carrier.

23. The process of claim 21 wherein said optically variable material is applied to said base web using an off-set printing or silk screening technique.

24. The process of claim 21 wherein said optically variable material is applied to said base web using a laser transfer technique.

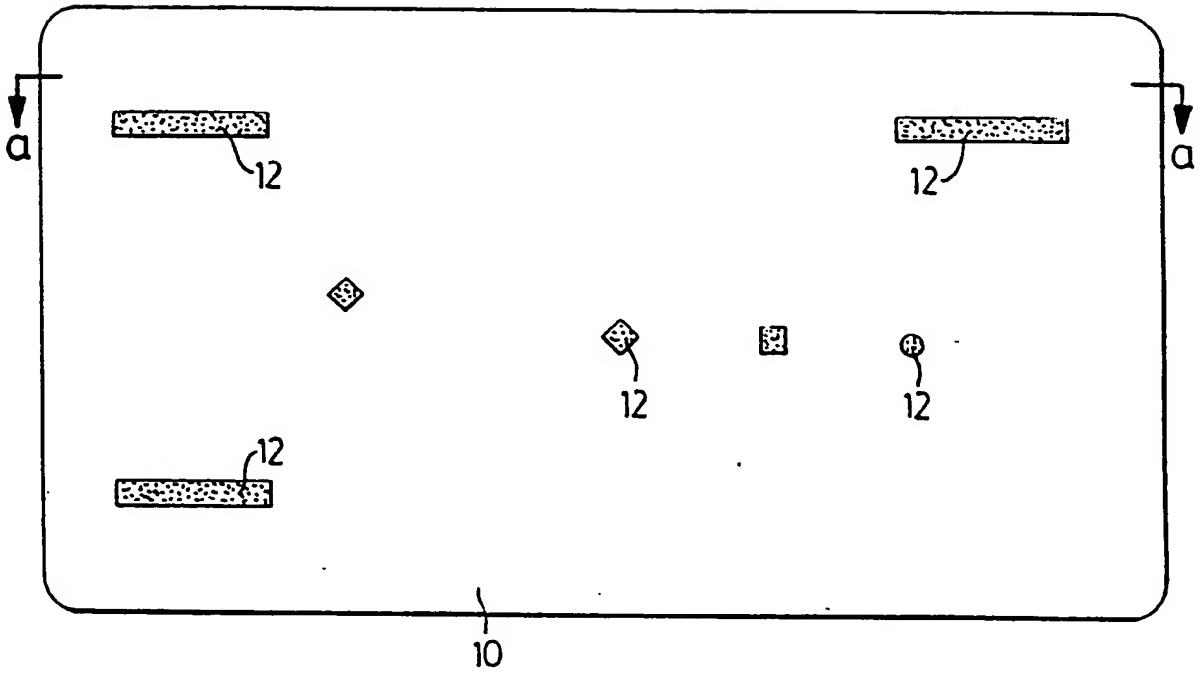


FIG. 1a

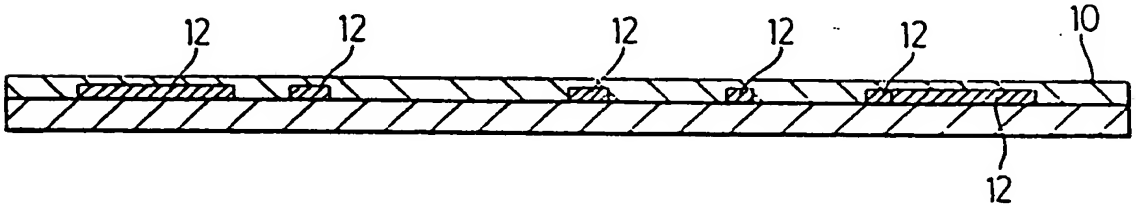
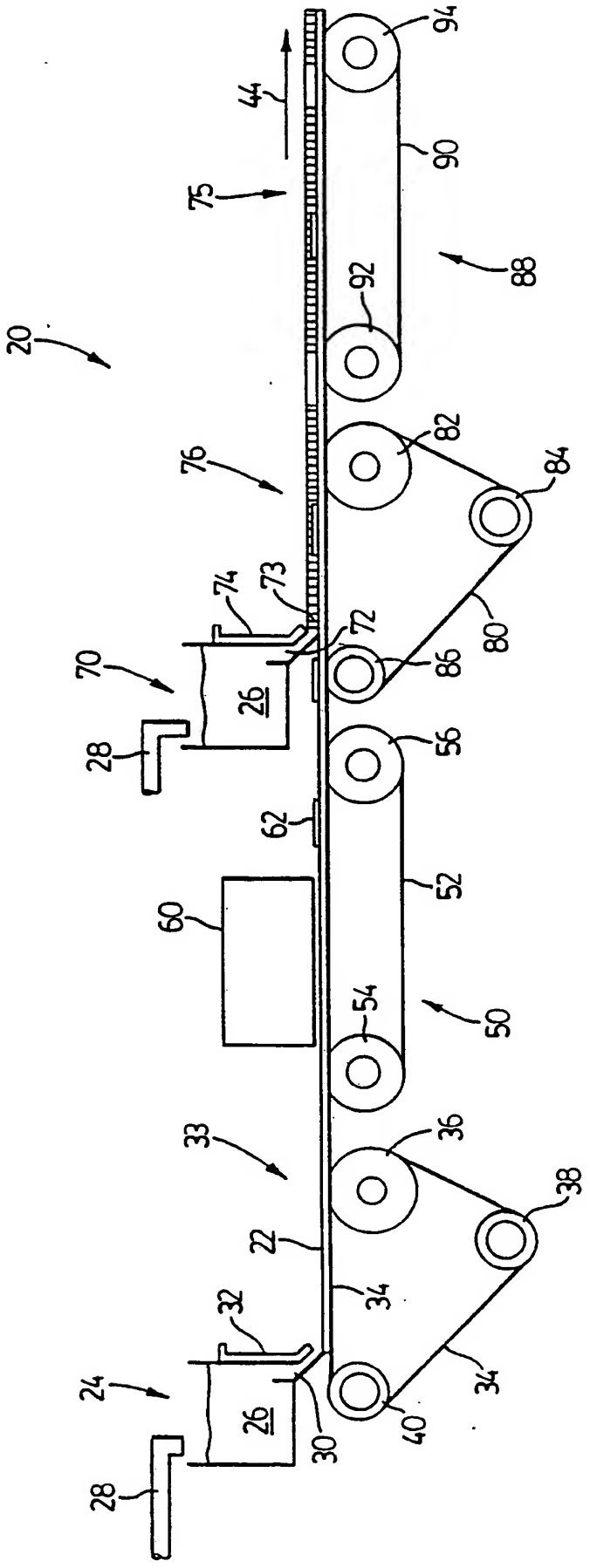


FIG. 1b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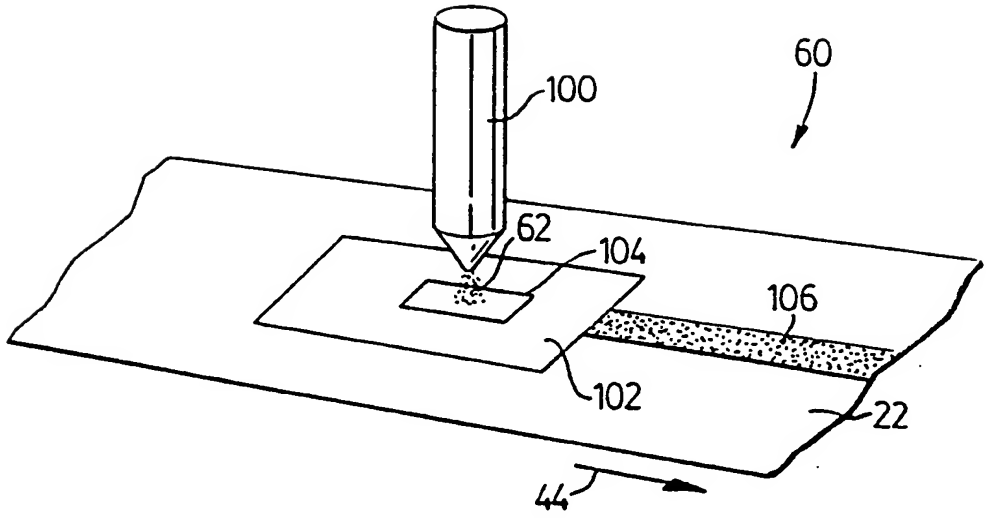
92
94

FIG. 2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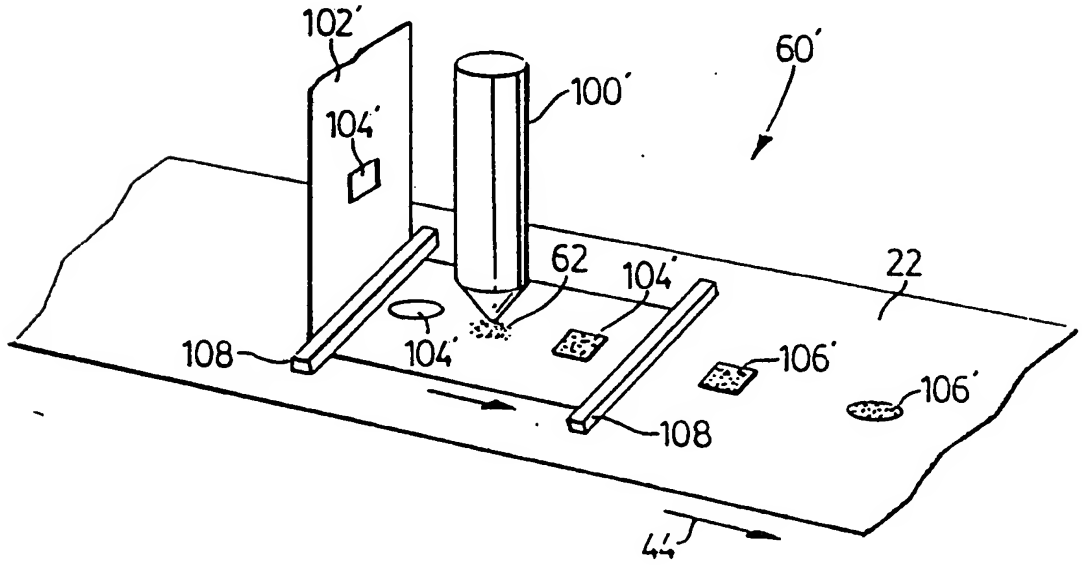
102
22
44

FIG. 3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100'
62
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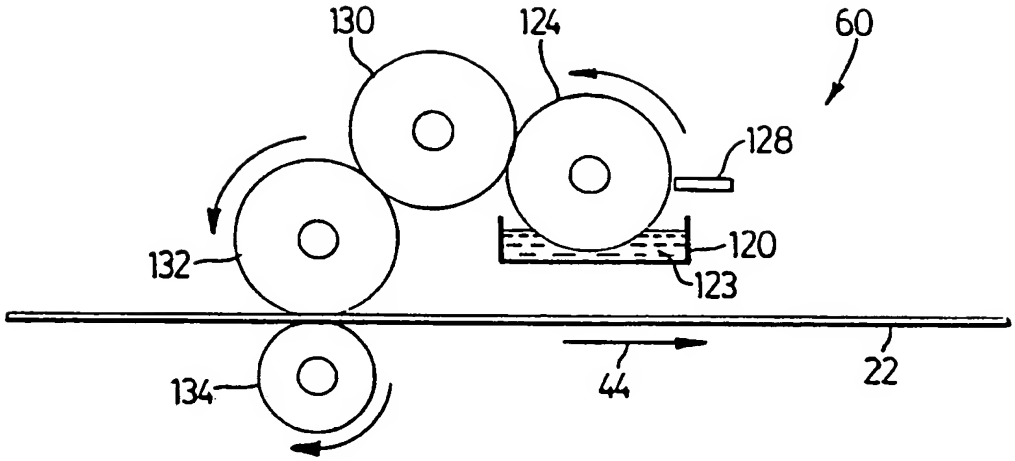
104'
106'
106'
108
44

FIG. 4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22

FIG. 5

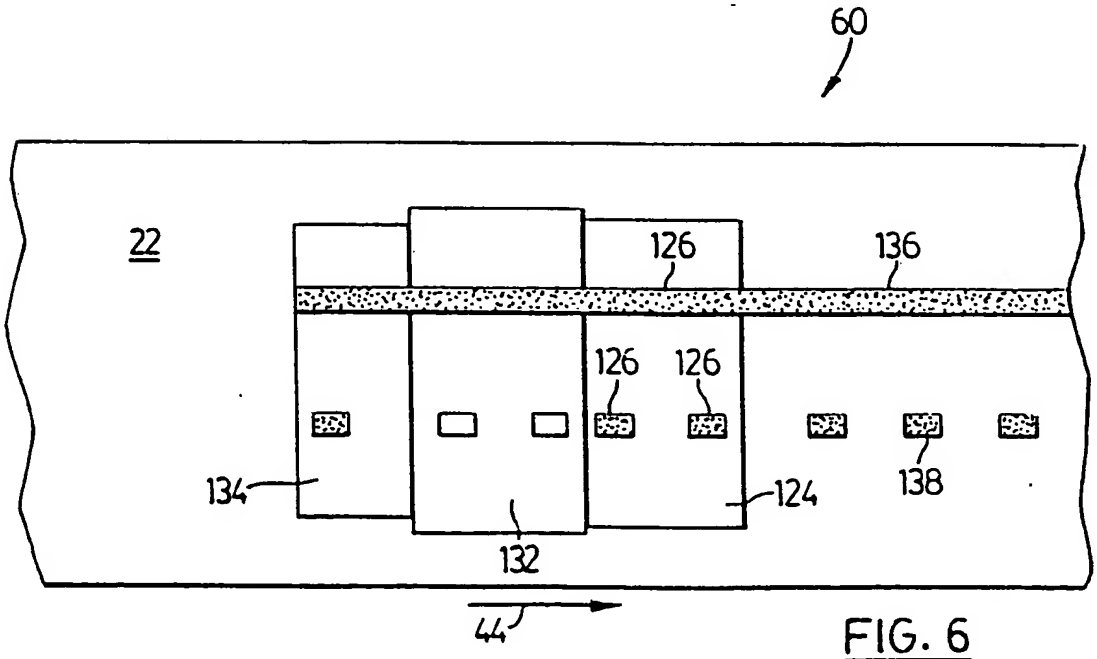
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FIG. 6

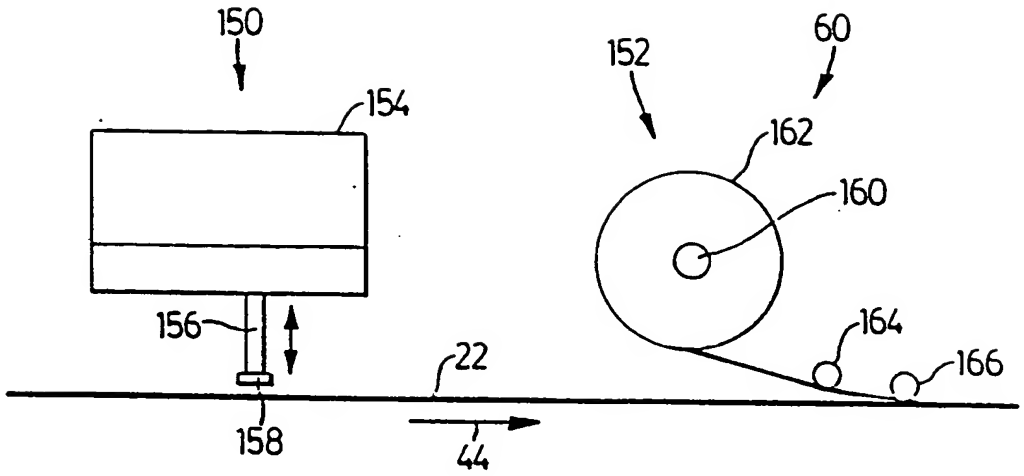
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FIG. 7

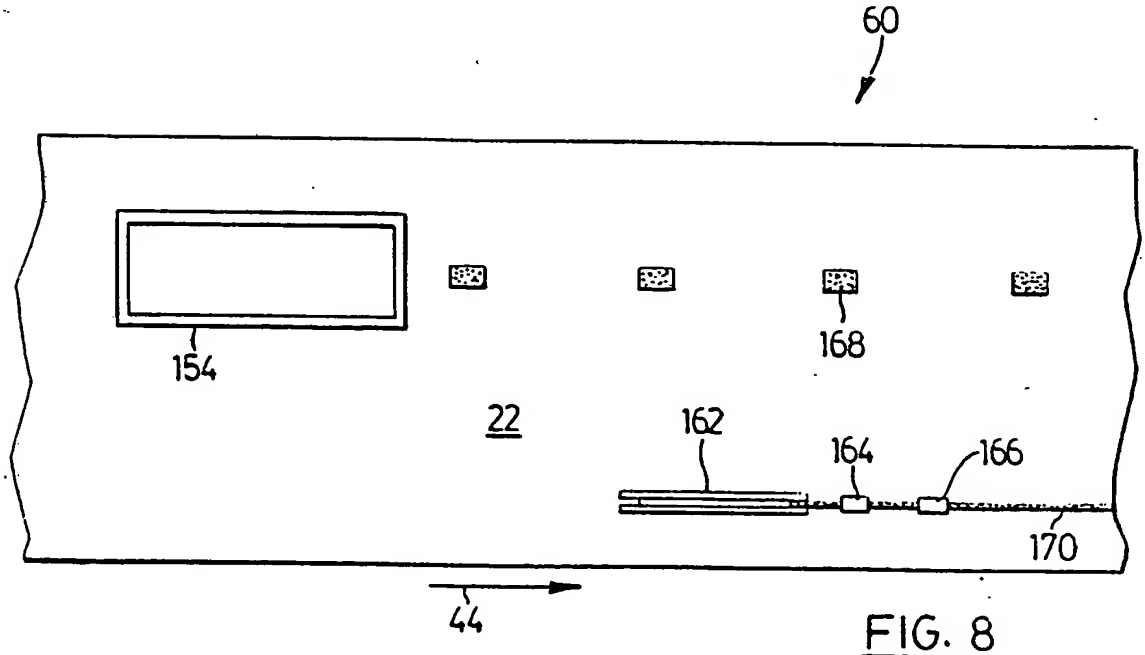
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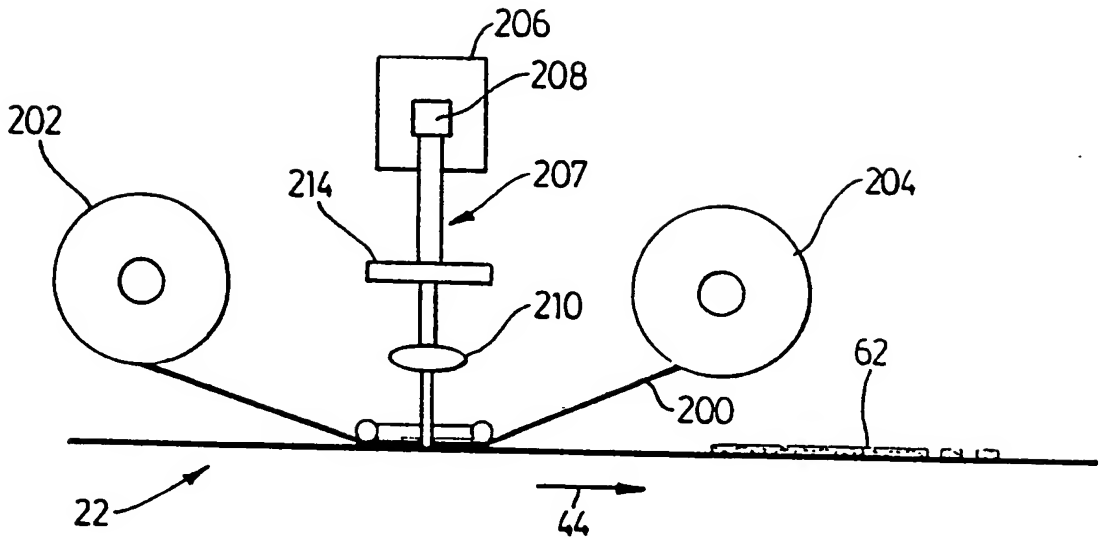
FIG. 8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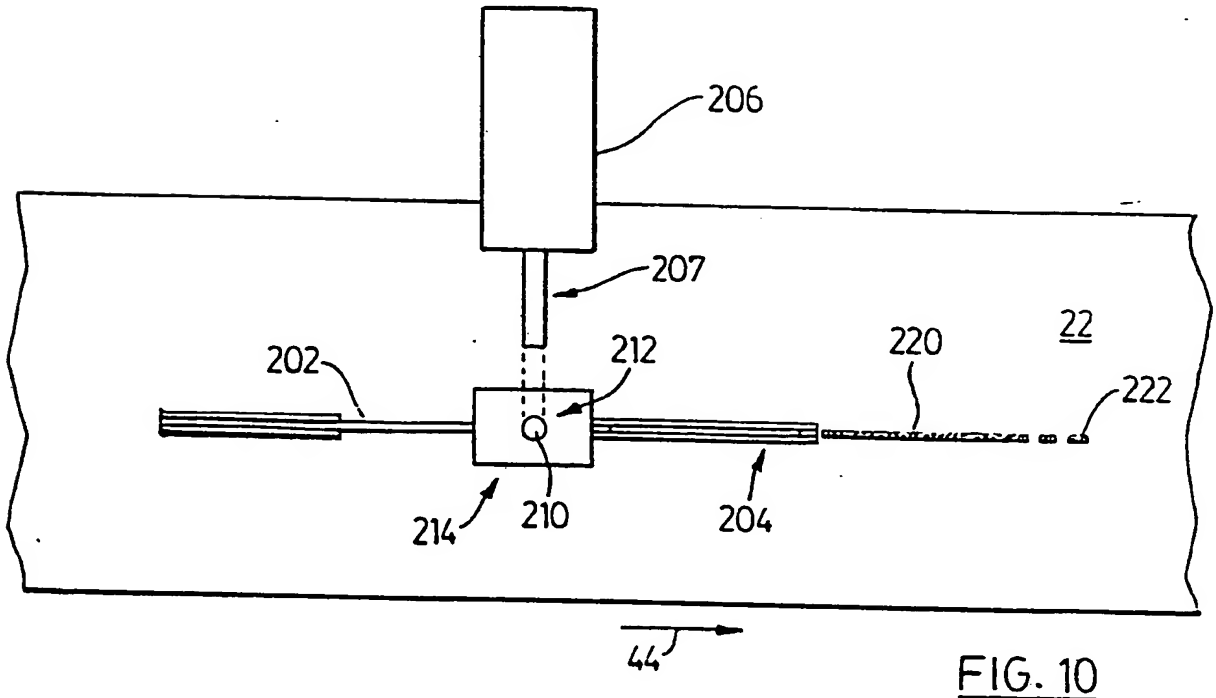
62
200
22
44

FIG. 9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44

FIG. 10

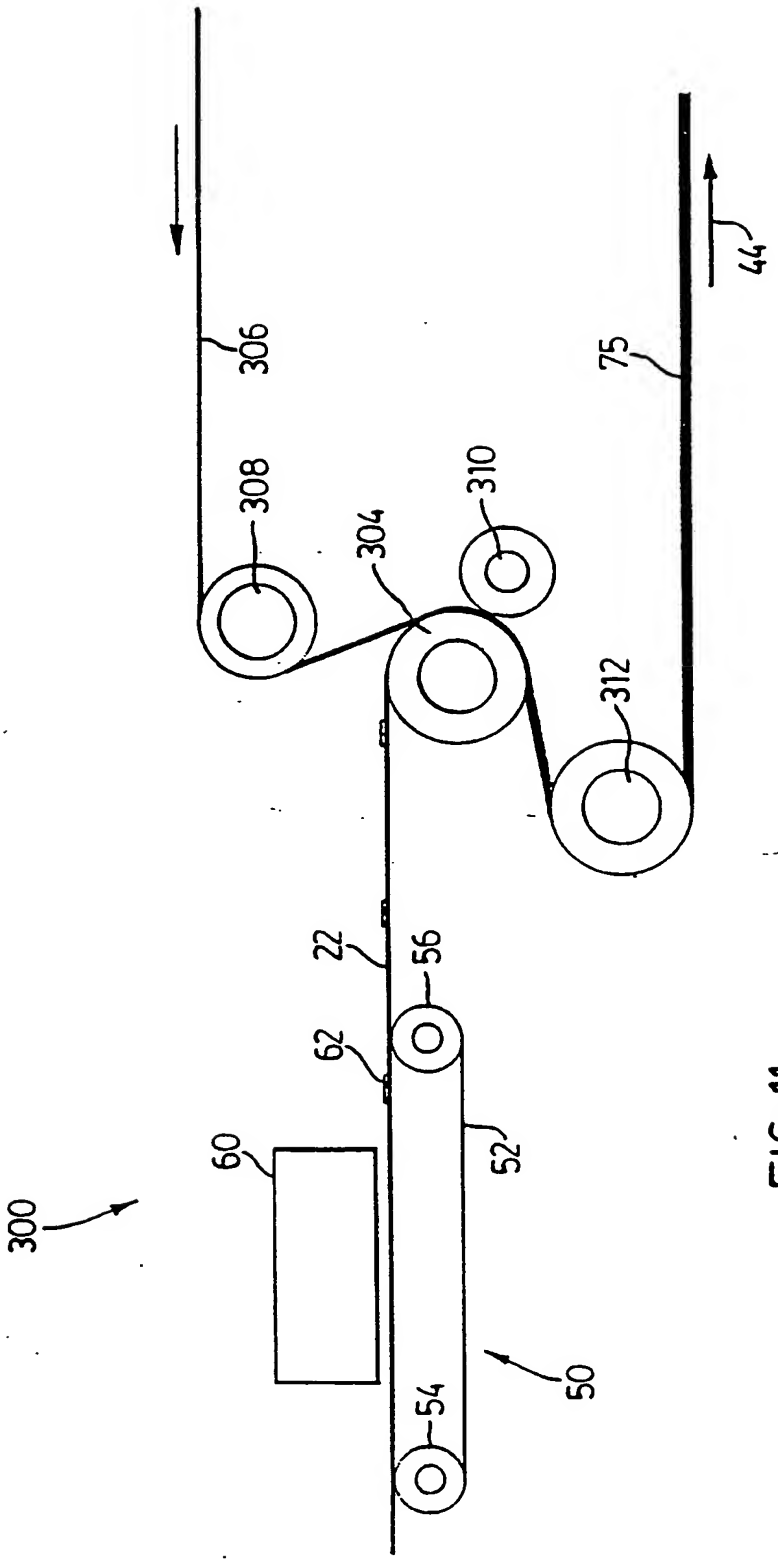

FIG. 11

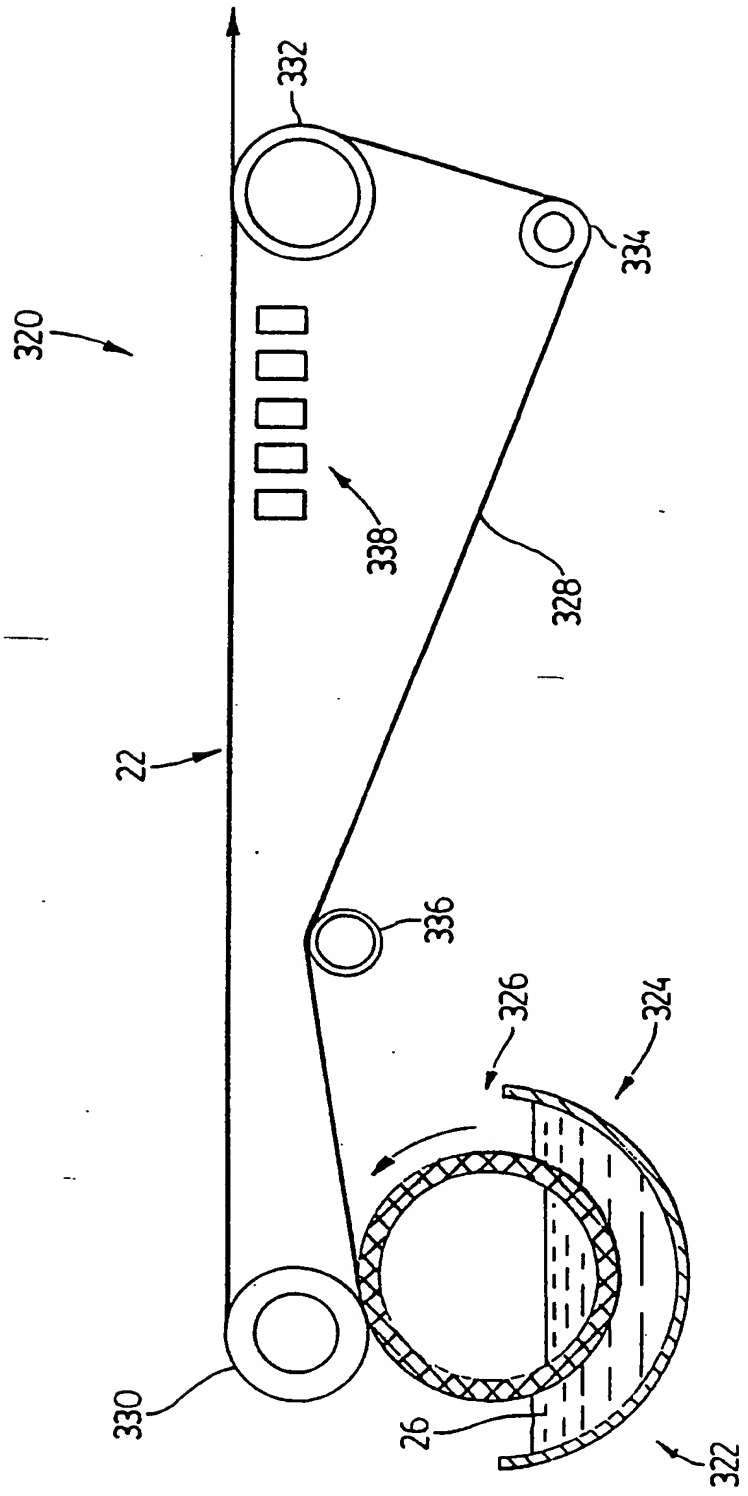

FIG. 12

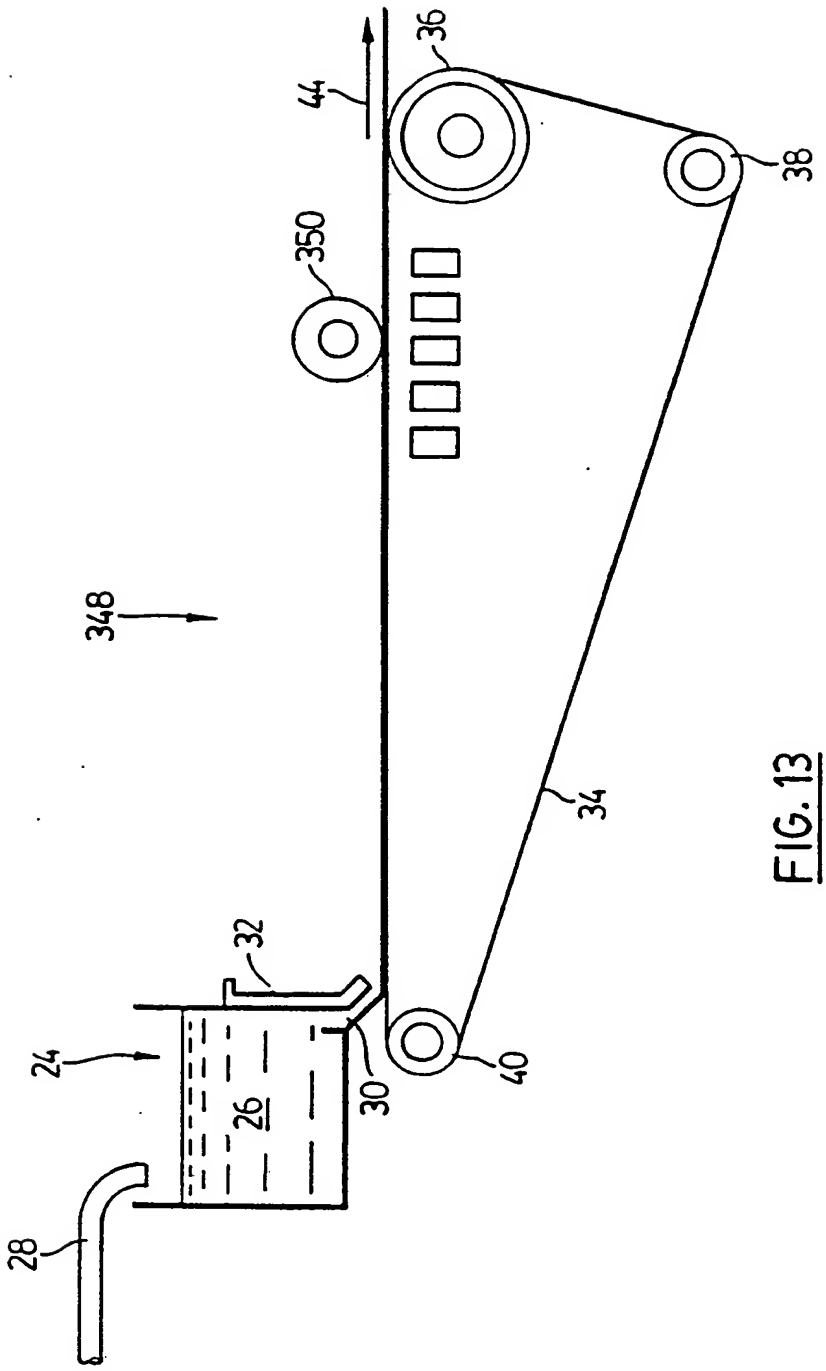

FIG. 13

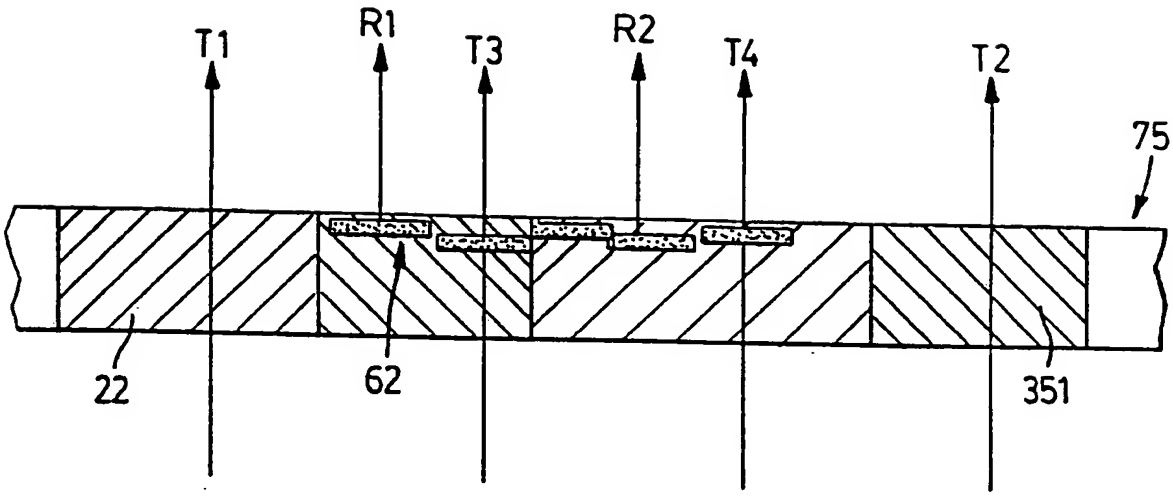

FIG. 14

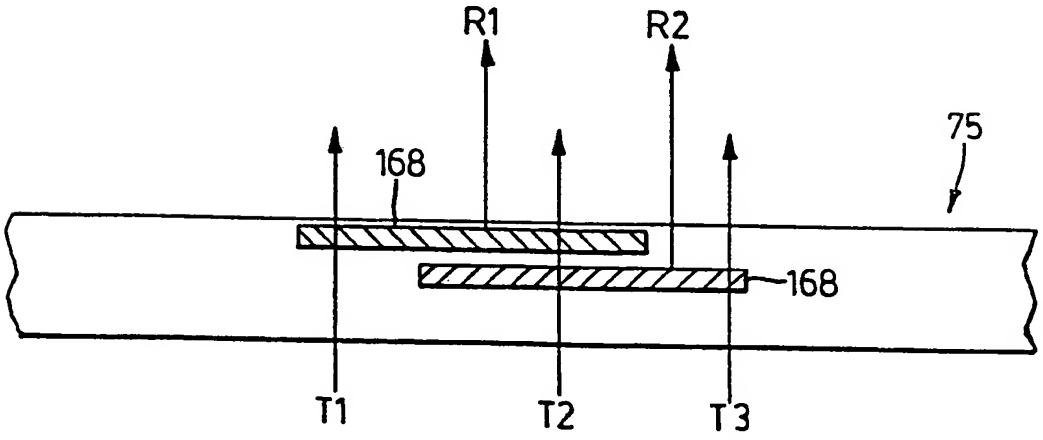

FIG. 15

INTERNATIONAL SEARCH REPORT

International Application No PCT/CA 93/00188

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 D21F1/44

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	D21F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
Y	EP,A,0 229 645 (GAO) 22 July 1987 see the whole document	1,9,11, 15-18,20
Y	US,A,4 534 398 (CRANE) 13 August 1985 see the whole document	1,9,11, 15-18,20
A	US,A,2 711 120 (J. D. MACLAURIN) 21 June 1955 see the whole document	2,3,5, 17,19, 20,22
A	FR,A,2 353 676 (WIGGINS TEAPE) 30 December 1977 see the whole document	7,8,23

° Special categories of cited documents :[10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
26 AUGUST 1993	09. 09. 93
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	DE RIJCK F.

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

CA 9300188
SA 73353

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-0229645	22-07-87	DE-A- 3601114	23-07-87
US-A-4534398	13-08-85	None	
US-A-2711120		None	
FR-A-2353676	30-12-77	DE-A- 2724681 JP-A- 52148208	22-12-77 09-12-77